

## NON-CONTACT ELECTRICAL ENERGY TRANSFER SYSTEM

Origin of the Invention

5           The invention described herein was made in the performance of official duties by an employee of the Department of the Navy and may be manufactured, used, licensed by or for the Government for any governmental purpose without payment of any royalties thereon.

Field of the Invention

10           The invention relates generally to energy transfer, and more particularly to a system that transfers electrical energy between two entities without requiring contact therebetween.

Background of the Invention

15           Electrical energy transfer between a source and a user has traditionally required some form of a hardwire connection or coupling in which physical contact is made between two conductors. However, there are many instances where such connections/couplings are difficult to design and make. For example, the hardwire coupling of an electrical energy source to a load in certain harsh environments (e.g., underwater, space, hostile air environments, etc.) generally requires complex and costly couplings to insure that such couplings are environmentally sealed before, during, and after the use thereof.

Summary of the Invention

20           Accordingly, it is an object of the present invention to provide a system and method that transfers electrical

energy between two conductors without requiring any physical contact therebetween.

Another object of the present invention is to provide a system and method of non-contact electrical energy transfer that can function in a variety of environments to include air, water and space.

Other objects and advantages of the present invention will become more obvious hereinafter in the specification and drawings.

In accordance with the present invention, a non-contact electrical energy transfer system has a ferromagnetic material formed into a nearly continuous loop that defines a gap between two opposing surfaces of the ferromagnetic material. A first electric conductor is coiled about a portion of the nearly continuous loop that opposes the gap. A block of the same ferromagnetic material is sized to loosely fit in the gap while being spaced apart from each of the opposing surfaces formed by the nearly continuous loop. A second electric conductor is coiled about a portion of the block. The block is spaced apart from the opposing surfaces when the block is fitted in the gap. Electrical energy applied to the first electric conductor induces an electric current in the second electric conductor when the block is positioned in the gap.

#### Brief Description of the Drawings

Other objects, features and advantages of the present invention will become apparent upon reference to the following description of the preferred embodiments and to the drawings, wherein corresponding reference characters indicate corresponding parts throughout the several views of the drawings and wherein:

FIG. 1 is a schematic view of a non-contact electrical energy transfer system illustrated in a non-energy transfer mode in accordance with the present invention;

FIG. 2 is a schematic view of the non-contact electrical energy transfer system in an energy transfer mode; and

FIG. 3 is a schematic view of one embodiment of the non-contact electrical energy transfer system used to transfer electrical energy from a submersible vehicle to an underwater vehicle in a water environment.

#### Detailed Description of the Invention

Referring now to the drawings, and more specifically to FIGs. 1 and 2, a non-contact electrical energy transfer system in accordance with the present invention is shown and is referenced generally by numeral 10. It is to be understood at the outset that energy transfer system 10 can operate in an air, water or space environment. By way of an illustrative example, one use of transfer system 10 will be described below as it relates to use in a water environment.

Energy transfer system 10 has a core 12 of a ferromagnetic material (i.e., iron, nickel, etc.) that is shaped to define a nearly continuous loop. That is, core 12 is discontinuous such that a gap 14 of width W is defined between ends 12A and 12B of core 12. Although the shape formed by core 12 is not a limitation of the present invention, core 12 is illustrated as a C-shaped core to take advantage of simple iron core transformer concepts. Accordingly, coiled about core 12 at a region thereof that opposes gap 14 is an electrical conductor 16 (e.g., wire, strip of material, a conductive run of material adhered to core 12, etc.).

Energy transfer system 10 further includes a block 18 of the same ferromagnetic material used for core 12. Preferably, the cross-sectional area of block 18 matches the surface area of each of ends 12A and 12B. Block 18 is sized such that its height H is less than width W. The amount of difference between these two dimensions should provide for a small space between block 18 and each of ends 12A and 12B when block 18 is positioned in gap 14 as will be explained further below. To maintain such spacing between block 18 and ends 12A and 12B, a sleeve 20 can be provided in gap 14 where cross-sectional area of sleeve 20 is configured/sized to slidably receive block 18. Sleeve 20 would typically be made from an electrically insulating material such as rubber, nylon, plastic or glass. Coiled about block 18 is an electric conductor 22 (e.g., wire, strip, a conductive run of material adhered to block 18, etc.).

When electrical energy transfer between conductors 16 and 22 is desired, block 18 is positioned in the gap (i.e., gap 14 illustrated in FIG.1 but not shown in FIG. 2 for sake of clarity) by sleeve 20 as shown in FIG. 2. With block 18 so positioned, electrical energy (e.g., an AC voltage) is applied to electric conductor 16 by an AC source 30. The resulting alternating current that passes through electric conductor 16 induces a magnetic field in core 12. The magnetic field flux lines are concentrated by core 12 as is well understood in the transformer field. The lines of flux pass through the windings of electric conductor 22 thereby inducing an electric current in conductor 22 that is supplied to a load 32. Electrical energy transfer will occur regardless of whether gap 14 is in an air, water or space environment. The inclusion of insulating sleeve 20 prevents any arcing from occurring if AC source 30 is activated while

block 18 is being positioned in sleeve 20.

The advantages of the present invention are numerous. Electrical energy transfer between two conductors is facilitated without requiring any direct physical contact between the conductors. The present invention simplifies electrical energy transfer in a variety of environments and can, therefore, be adapted for a wide variety of applications. For example, as illustrated in FIG. 3, the present invention simplifies electrical energy transfer between a submersible vehicle 100 and an underwater vehicle 102. Specifically, submersible vehicle 100 has core 12 mounted thereon such that gap 14 is submerged in water 200 and accessible from water 200. Underwater vehicle 102 has block 18 mounted thereon (e.g., extended from the nose thereof as shown) such that block 18 can be inserted into sleeve 20 and gap 14. The particular mounting sleeve used for block 18 is not a limitation of the present invention. AC source 30 on submersible vehicle 100 can be, for example, an onboard AC generator while load 32 (on underwater vehicle 102) can be a battery charging system, the choice of which is not a limitation of the present invention.

Although the invention has been described relative to a specific embodiment thereof, there are numerous variations and modifications that will be readily apparent to those skilled in the art in light of the above teachings. For example, the present invention is not limited to energy transfer between underwater vehicles as it can be used equally as well for vehicles that operate in air or space environments. Furthermore, the present invention is not limited to electrical energy transfer between vehicles as it can be used equally as well for electrically coupling stationary systems such as electrical cables. It is

therefore to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described.

5           What is claimed as new and desired to be secured by Letters Patent of the United States is: